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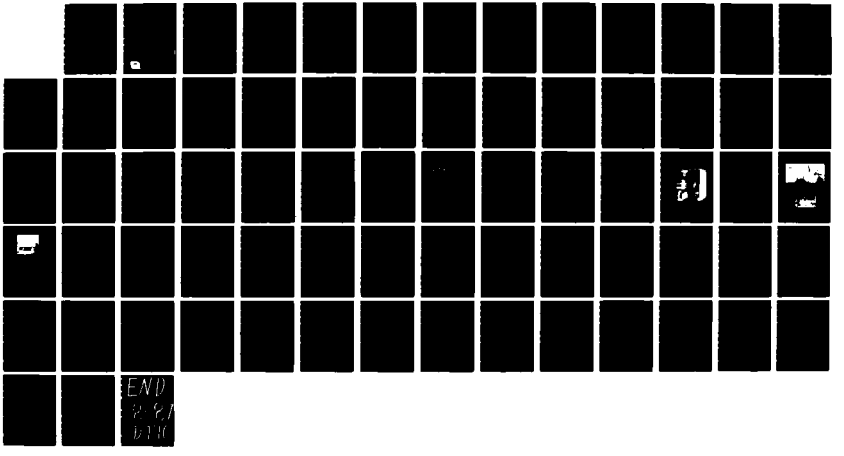

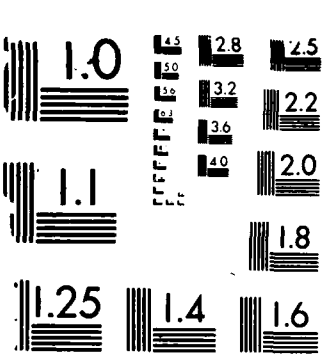

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IDA PAPER P-1973

SIMULATION TRAINERS FOR TANK GUNNERY

John Metzko

February 1987

Prepared for
Assistant Secretary of Defense
(Reserve Affairs)

INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311

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This report describes an evaluation of five developmental tank gunnery simulators for use by the Army reserve components. Although the devices are evaluated for use by the Army Guard and Reserve, they are logical candidates for use by the Active Army as well. The evaluation is an assessment of the utility, in terms of the number of tasks trained, and the expected unit cost of each simulator relative to the others. The measure of merit is cost-per-task-trained, where tasks are weighted in importance for several types of engagements. Differences in training level (basic, intermediate, and advanced) and in design emphasis may make a pair of simulators appear to be complements more than competitors.

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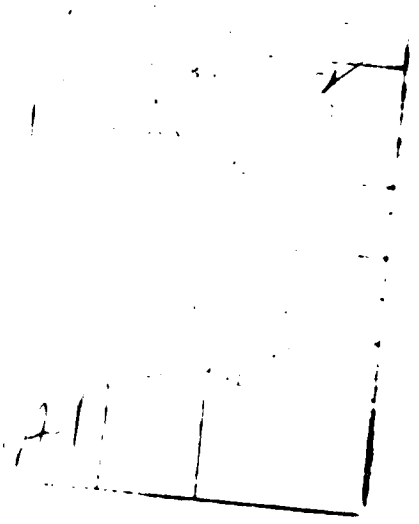

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FOREWORD

This document is one of four reports on work performed by the Institute for Defense Analyses for the Office of the Assistant Secretary of Defense (Reserve Affairs) since August 1985 under Task Order T-M2-266, "Reserve Component Training Technology." While the task is concerned with the reserve components (RCs) of all the Services, our effort to date has been focused on the Army Guard and Reserve.

The first report, IDA Paper P-1971, "Army Reserve Component Training Technology, A Progress Report (U)," (1987), (1) describes the methodology of our investigation of Army RC training, (2) presents a statistical description of the environment for that training, and (3) provides other information that we expect to be useful for our continuing look at the Army RCs.

The second report, IDA Paper P-1972, "Training State of a Group of Army Combat Service Support Units," (1987), is an assessment of the state of training of Guard and Reserve units that perform combat logistics functions, i.e., maintenance and movement of equipment, supplies, and personnel; it is the only one of the four reports that is classified (Confidential).

This report, IDA Paper P-1973, describes an evaluation of tank gunnery devices for use by the Army RCs.

The fourth report, IDA Memorandum Report M-255, "Initial Assessment of Maintenance Training of Army Reserve Components," (1987), is a preliminary examination of Army RC maintenance training to identify area(s) for analysis.

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ABBREVIATIONS

EIDS	Electronic Information Delivery System
GF1	Guardfist 1
GF2	Guardfist 2
IDA	Institute for Defense Analyses
K	thousand
M-COFT	Mobile Conduct of Fire Trainer
MILES	multiple integrated laser engagement system
PM-TRADE	Project Manager for Training Devices
RC	Reserve component
TGMTS	Tank Gunnery and Missile Tracking System
TWGSS	Tank Weapons Gunnery Simulation System
VIGS	Videodisc Gunnery Simulator

SUMMARY AND DISCUSSION

This analysis evaluates five developmental tank gunnery simulators for use by the Army Reserve components (Guard and Reserve): (1) Tank Gunnery and Missile Tracking System (TGMTS), (2) Mobile Conduct of Fire Trainer (M-COFT), (3) Videodisc Gunnery Simulator (VIGS), (4) Tank Weapons Gunnery Simulation System (TWGSS), and (5) Guardfist 1 (GF1) (see Section I.C and Appendix A for descriptions).

The use of tank gunnery simulators is a recent innovation in Army training strategy. Because of this circumstance, the Army does not yet have a base of data that relates training effectiveness to the use of such devices. Favorable cost-effectiveness experience with simulators in other military training (e.g., aircraft crews) provides reason to expect similar advantages for simulator training of tank crews. However, the absence of effectiveness data leads us to evaluate tank gunnery simulators on the basis of their expected capabilities to train tasks that the crew members would perform in combat. The evaluation is thus an assessment of the utility--in terms of the number of tasks trained--and the cost of each simulator relative to the others.

The five simulators are not all designed to train tank crews at the same levels (basic, intermediate, and advanced) of gunnery. In at least one comparison they may be viewed as complements rather than competitors. In that case, both GF1 and TWGSS are full-crew, tank-mounted systems with nearly equal expected costs. But while GF1 is designed for procedural gunnery training in the armory (basic and intermediate levels), TWGSS is designed for precision gunnery training on the range

(advanced level). The Army's Armor School understandably sees roles for both in its armor training strategy.

The first units of M-COFT became operational in FY 1986. Production of TGMTS and VIGS is expected to begin in FY 1987. The developments of TWGSS and GF1 have just recently begun. The dissimilarities in developmental stages of the simulators do not negate the value of making comparisons. Consider M-COFT and GF1, both of which are gunnery procedures trainers that are about five years apart in their evolving lives: One might want to consider the expected utility and cost of the downstream GF1 when making investment plans for the now-available M-COFT.

Cost-per-task-trained (expected unit cost divided by utility score) is used as the measure of merit in evaluating the five simulators. Results of the analysis are shown in Table S-1, where three alternative systems were used to assign importance-related values to crew duties in six basic types of engagements: (1) stationary tank vs. stationary target, (2) stationary tank vs. moving target, (3) stationary tank vs. multiple targets, (4) moving tank vs. stationary target, (5) moving tank vs. multiple targets, and (6) moving tank vs. simultaneous targets.

The first observation about the Table S-1 results is that the measure of merit is nearly insensitive to the system used for valuing task importance.

A second observation is that the results raise several issues, which are not immediately answerable, concerning near-term investments in tank gunnery simulators: Does the training efficiency (cost-per-task-trained) of VIGS make up for its limited utility (number of tasks trained)? Should the potential use of GF1 affect investment decisions on TGMTS, which has 1/3 GF1's training efficiency, and M-COFT, which is 1/40 as efficient as GF1? Should the development of GF1 be accelerated to improve its competitiveness in investment analyses?

TABLE S-1. UTILITY AND COST-PER-TASK-TRAINED OF TANK GUNNERY SIMULATORS

Simulator	Expected Unit Cost FY 1986$	Utility Score Based on Value System Indicated			Cost-Per-Task-Trained Under Value System Indicated[d]		
		1/2[a]	2[b]	1[c]	1/2[a]	2[b]	1[c]
TGMTS	125,000	188	140	118	665	893	1,059
M-COFT	1,900,000	220	180	130	8,636	10,556	14,615
VIGS	14,000	139	112	82	101	125	171
TWGSS	100,000	460	362	279	217	276	358
GF1	96,000	455	356	277	211	270	347

[a] More important tasks are assigned values of 2; other tasks are assigned values of 1. See Section II.A.2 for discussion of task importance.

[b] Only tasks with value 2 are counted.

[c] All tasks are valued equally and assigned values of 1.

[d] For tasks in six different types of engagements.

The development and procurement of M-COFT--a stand-alone, trailer-mounted, computer-based gunnery simulator--implies Army satisfaction with its utility and cost for use by Guard and Reserve units. By that standard, the Army should warmly welcome GF1, which would train twice as many tasks at five percent of the cost. This result was not unexpected since a preliminary analysis indicated that we could expect a 1:16 advantage in life cycle cost per trainee for GF1 over M-COFT.[1]

The large superiority of GF1 in cost-per-task-trained should not be the only consideration in a comparison of GF1 and M-COFT. The instructional capability of M-COFT is largely a product of a well-developed instructional system that directs, monitors, and evaluates the training process. Whether GF1 will be comparable in instructional capability will depend on characteristics and capabilities of the instructional system that is developed for GF1.

A final observation from Table S-1 is that GF1 and TWGSS are expected to be equally efficient in their complementary training roles.

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[1] That analysis used the expected life cycle cost of Guardfist 2 (GF2), a second Guard-initiated simulator concept for training artillery system personnel, as an indicator of the cost of a single-videodisc system. Whereas GF2 needs only one videodisc unit--for the forward observer--GF1 needs three videodisc units--for the tank commander, the gunner, and the driver. As a first order approximation, Army cost estimates for GF2 were simply multiplied by three and then compared to similar estimates for M-COFT.

I. INTRODUCTION

A. BACKGROUND

In August 1985, IDA began an investigation of technology, training devices, and procedures to train Army reserve components (the Guard and the Reserve); our study sponsor is the Office of the Assistant Secretary of Defense (Reserve Affairs). Part of that investigation involved reviewing the process by which the Army develops training devices; special attention was given to the issue of training device applicability to the reserve components (RCs), which are a dispersion of many small training-target populations.

Our review of the training device development process revealed that the Army Guard had proposed training requirements for two devices, which appeared particularly well suited to RC training. These represent the only training device requirements formulated by either of the Army RCs. The devices would provide (1) full-crew tank gunnery training and (2) training of all components--viz., forward observer, fire direction center, and weapon crew--of field artillery batteries and mortar platoons. Interactive videodisc technology is central to the Guard concepts for these full-crew simulation trainers, which are identified as Guardfist 1 (armor) and Guardfist 2 (artillery). The use of interactive videodisc technology is attractive for training the RCs because of its relatively low cost, particularly when compared to the costs of more complicated types of simulators.

Because (1) there are in development several more simulation trainers for tank gunnery than for artillery fire support and (2) financial resources constrain the scope of work following

our initial investigation, the study sponsor agreed that IDA should focus its continuing effort on tank gunnery training.

B. OBJECTIVE

The purpose of this analysis is to evaluate, for Army RC use, developmental devices that are designed for tank gunnery training. "Devices" in this analysis means "simulation trainers" as opposed to subcaliber devices used for limited-range firing, training aids (such as extension course films) that supplement gunnery training, and calibration devices (such as boresight and ranging devices).

C. APPROACH

Discussions with personnel at the Department of the Army Headquarters, National Guard Bureau, Army Training And Doctrine Command, Army Training Support Center, and Armor School failed to identify previous studies that related tank gunnery training devices to performance in combat (also called "transfer of training"). And, these discussions identified only a single report that provided objective data on the training effectiveness of tank gunnery devices. That report describes a six-day, live-fire test at Gowen Field (Boise), Idaho in 1982 (Ref. 1). The test results indicated that crewmen who trained only with simulation equipment were as capable of hitting targets as crewmen who followed a standard training program in which operational equipment together with subcaliber and full caliber ammunition is used.

The paucity of data to support the effectiveness of simulation trainers for tank gunnery is a reflection of the relatively recent introduction of such devices. While flight simulators have been used for several decades for military and civil flight training--and their use has been subjected

to several studies that reported their cost-effectiveness (see Refs. 2 and 3)--the Army has had little experience with armor gunnery simulators. Indeed, the Army's current catalog of training devices, which was printed in 1980, shows only one simulation trainer for tank gunnery (Ref. 4); that device is the Conduct of Fire Launcher Trainer, which is appended to armor vehicles that carry the Shillelagh missile.

Today we find five different simulation trainers for tank gunnery in various stages of development, where "development" means the device might be in any stage from "conceptual" to "procurement-not-completed". These simulators are described briefly below, based on data in Refs. 5 through 14; more details are provided in Appendix A.

Tank Gunnery and Missile Tracking System (TGMTS)

This is a rear screen projection system that provides a film presentation of actual armor vehicles in a realistic scenario. The primary use of TGMTS is for coordination of gunner and tank commander during engagement exercises. Procurement is scheduled to be initiated in mid-1987.

Mobile Conduct of Fire Trainer (M-COFT)

This is a stand-alone trailer-mounted gunnery simulator that uses computer-based visual simulation to provide action scenes in which tank commanders and gunners can see and interact with dynamic, multiple-target situations. Procurement of MCOFT began in FY 1986.

Videodisc Gunnery Simulator (VIGS)

This simulator is a table-top device, which trains a gunner in the proper techniques of engaging targets and utilizing primary and secondary guns, replicates a gunner's controls and provides him a realistic through-the-sight view of the engagement scene. Procurement of VIGS is to begin in early FY 1987.

Tank Weapons Gunnery Simulation System (TWGSS)

This is a tank-mounted main gun device designed to simulate the exact trajectory of a projectile in real time. It will interface with the tank's fire control system and be useable on ranges for gunnery exercises in which simulated tracer and impact indications will be superimposed in the sight picture. An ongoing evaluation of several tankmounted simulators used by European armies is expected to lead to selecting a candidate for procurement in the late 1980s to fulfill the Army's TWGSS requirement.

Guardfist 1 (GF1)

This device, whose acronymic name stands for "Guard Unit Armory Device Full-Crew Interactive Simulation Trainer", is also a tank-appended simulator that provides the illusion of movement by color video inputs to sights and periscopes; the movement will be interactive with all tank controls. Each crew member will view the terrain and the engagement scenes from the perspective of his duty position. Recent initiation of development is expected to lead to procurement in the early 1990s.

The unavailability of empirical effectiveness data at this time leads us to evaluate tank gunnery trainers on the basis of their capabilities to enable crew members to simulate those duties (or tasks) they would perform in real tank combat. This information is available as part of functional specifications or task analysis for each simulator. Thus, the evaluation is an assessment of the utility and cost of the five simulation trainers relative to each other.

As discussed in the next section, "utility" is measured by the number of tasks a simulator can train. Adoption of that utility measure implies two assumptions. First, all simulators will train those crew duties that they are designed

to train. The evaluation compares TWGSS and GF1, whose designs have yet to be proven (Will they in fact train those tasks they're expected to train?), to M-COFT, which is in use today, and to TGMTS and VIGS, whose procurements are about to be initiated.

The second assumption is that training crew duties for any level of gunnery--basic, intermediate, or advanced--is as important as training those duties at other levels (i.e., training at all levels is necessary to produce competent tank crews). The evaluation compares devices that, in some cases, could be viewed as complements rather than competitors. While there is variously commonality among the five devices with respect to simulating crew positions, crew member duties, and types of engagements that can be played, there are also significant differences in simulation fidelity (to actual combat environments) that could make one device complement another. For example, GF1 appears well suited to training gunnery procedures at the armory, while TWGSS, which is also a full-crew, tank-mounted system, is to be used for precision (laser) gunnery on the range. If TWGSS and GF1 fulfill their design promises, the Army might well want both.

In another case, comparability of simulators is hindered by a difference in development maturity and thus uneven knowledge about details of final design characteristics and capabilities of the training devices. This case involves GF1 and M-COFT, which are procedural trainers for use at the Armory. In this case, M-COFT, which is about five years ahead of GF1 in its development life, has a well-defined instructional subsystem that directs, monitors, and evaluates the training process. This instructional subsystem--which includes a library of preprogrammed exercises that teach skills in target acquisition, reticle aiming, and tank systems management; an adaptive evaluation system for measuring crew progress; a

training management system that processes trainee records and schedules next exercises; and an instructor/operator station that provides an instructor real-time feedback and controls for monitoring and analyzing trainee actions--embodies a substantial part of the instructional capability of M-COFT. The extent to which the instructional capability of GF1, whose development was just recently initiated, can match that of M-COFT will depend largely on the characteristics and capabilities that will be built into the instructional subsystem that is developed for GF1.

II. ANALYSIS

A. UTILITY

Reference 5, a supplement to the U.S. Army Armor School's FM 17-12 tank gunnery manuals (Refs. 15, 16, and 17), identifies specific tank crew duties associated with various types of tank gunnery engagements. Six basic types of engagements are: (1) stationary tank vs. stationary target, (2) stationary tank vs. moving target, (3) stationary tank vs. multiple targets, (4) moving tank vs. stationary target, (5) moving tank vs. multiple targets, and (6) moving tank vs. simultaneous targets.

1. Tank Gunnery Tables

"Gunnery tables" and "tactical tables" are terms the Army Armor community uses for tank combat exercises (in tankers' lexicon, a "table" is an "exercise"). Gunnery tables, which train armor crews to hit targets, include tasks, conditions, and standards based on Armor School analysis of gunnery engagement factors. These tables reflect hit or kill probabilities of U.S. tanks operating against threat tanks and anti-tank weapons (Refs. 15, 16, and 17). Table 1 identifies twelve tank gunnery tables that are designed to ensure that crew members are progressively trained in basic, intermediate, and advanced gunnery engagements.

Tactical tables use gunner proficiency and multiple integrated laser engagement systems (MILES) to train tank crews to respond rapidly to enemy activity so that targets can be destroyed. Tactical tables incorporate the factors of mission,

TABLE 1. TANK GUNNERY EVALUATION TABLES[a]

Table[b]	Description
Table I	Basic Gunnery Skills (Individual)
Table II	Basic Gunnery Course (Individual/Crew)
Table III	Basic Training Course (Crew)
Table IV	Basic Qualification Course (Crew)
Table V	Machine Gun Training
Table VI	Main Gun Calibration (Live-Fire Accuracy Screening Test) and Preliminary Main Gun Training
Table VII	Intermediate Training Course (Crew/Tank with Wingman)
Table VIII	Intermediate Qualification Course (Crew/Tank with Wingman)
Table IX	Advanced Training Course (Section)
Table X	Advanced Qualification Course (Section)
Table XI	Advanced Training Course (Platoon)
Table XII	Advanced Qualification Course (Platoon)

[a] Source: Refs 15, 16, and 17.

[b] "Table" means "exercise that demonstrates proficiency achieved in that portion of the training program".

enemy, terrain, and troops in unit training. These tables are similar in format to the gunnery tables (Refs. 15, 16, and 17) but are broader in scope.

2. Tasks Trained

Reference 14 contains over 30 pages of devices-vs.-duties matrices indicating the applicability of various devices for training tasks in the six basic gunnery engagements shown above. In these matrices, the Armor School identifies tasks that can be trained, or are expected to be trained, by the five simulators of interest to us. (Data in these matrices pertaining to the applicability of subcaliber training devices and supplementary training aids are not used in this analysis.)

The Armor School's devices-vs.-duties matrices reflect a simple binary system ("Yes" or "No") to indicate the ability of a given device to train a specific task. Because all tasks appear not to be equally important, arrangements were made for master gunners at the Armor School to rate the importance of the different crew duties.[1]

All duties are important in the sense that their performance is required for the tank crew to operate properly. However, "importance" in our rating system reflects two other senses. First, the intrinsic value of some tasks to effective crew performance in combat or in an exercise is obviously greater than the value of other tasks. For example, turning the main gun switch ON is essential to complete the firing circuit so that a round can be fired, whereas turning that switch OFF introduces the less serious consequence of a postfiring hazard if another round is loaded and the firing button is pushed inadvertently.

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[1] In response to a request for experienced subject matter experts to evaluate task importance, the Office of the Commandant, U.S. Army Armor School selected four master gunners to provide advice on task importance.

In a second sense, some tasks, such as "acquire and identify target", need a more complete or explicit simulation than do other tasks, such as "issue fire command", which can be easily simulated by mental exercise. Thus, need for a physical device to facilitate simulation is another criterion of importance.

The scale for rating importance was also left to the master gunners at the Armor School. They decided that tasks for which the simulation device is important should be assigned a value of 2. Tasks that on their own did not appear to justify a device should be given a value of 1.

The importance ratings of the Armor School master gunners are shown in Appendix B, which contains tables that indicate the capabilities of the five simulators to train tasks for the six basic types of engagements. All data in these tables are from the Army's supplement (Ref. 5) to its tank gunnery manuals and from the master gunners (Ref. 18).

Aggregate utility results for the five simulators used in the six types of engagements are shown in Tables 2, 3, and 4, where different value systems have been used to score the devices. Table 2 reflects the 1-2 value system selected by the master gunners. Table 3 reflects a system in which only those tasks that were assigned values of 2 (need explicit simulation) by the master gunners are counted. And Table 4 results are based on the assumption that all tasks are valued equally at 1.

The utility results are seen to be insensitive to the value system used. The utility rank order is the same in all three cases. And some division calculations confirm that normalized scores vary little with changes in value system.

TABLE 2. UTILITY OF TANK GUNNERY SIMULATORS - ALL TASKS VALUED 1 OR 2

Type of Engagement and Crew Member	Maximum Score	Simulator				
		TGMTS	M-COFT	VIGS	TWGSS	GF1
Sta Tank/Sta Tgt[1]						
Commander	19	14	16	13	19	19
Gunner	32	28	32	29	32	28
Loader	16	12	0	0	14	14
Driver	6	2	0	0	6	6
	73	56	48	42	71	67
Sta Tank/Mov Tgt[2]						
Commander	19	14	14	12	17	19
Gunner	39	35	39	37	39	37
Loader	16	12	0	0	14	14
Driver	6	4	0	0	6	6
	80	65	53	49	76	76
Sta Tank/Mult Tgts[3]						
Commander	24	19	19	18	24	24
Gunner	34	30	34	28	34	30
Loader	18	14	0	0	16	16
Driver	6	4	0	0	6	6
	82	67	53	46	80	76
Mov Tank/Sta Tgt[4]						
Commander	21	0	14	0	21	21
Gunner	38	0	21	0	32	34
Loader	16	0	2	2	13	14
Driver	11	0	0	0	11	11
	86	0	37	2	77	80
Mov Tank/Mult Tgts[5]						
Commander	26	0	11	0	26	26
Gunner	38	0	7	0	38	34
Loader	18	0	0	0	16	16
Driver	11	0	0	0	11	11
	93	0	18	0	91	87
Mov Tank/Simul Tgts[6]						
Commander	21	0	5	0	15	21
Gunner	35	0	6	0	33	31
Loader	15	0	0	0	13	13
Driver	4	0	0	0	4	4
	75	0	11	0	65	69
Totals	489	188	220	139	460	455

1 Stationary Tank/Stationary Target
2 Stationary Tank/Moving Target
3 Stationary Tank/Multiple Targets
4 Moving Tank/Stationary Target
5 Moving Tank/Multiple Targets
6 Moving Tank/Simultaneous Targets

TABLE 3. UTILITY OF TANK GUNNERY SIMULATOR - ONLY TASKS WITH VALUE 2 CONSIDERED

Type of Engagement and Crew Member	Maximum Score	Simulator				
		TGMTS	M-COFT	VIGS	TWGSS	GF1
Sta Tank/Sta Tgt[1]						
Commander	14	10	12	8	14	14
Gunner	28	24	28	24	28	24
Loader	10	6	0	0	8	8
Driver	4	0	0	0	4	4
	56	40	40	32	54	50
Sta Tank/Mov Tgt[2]						
Commander	14	10	10	8	12	14
Gunner	36	32	36	34	36	34
Loader	10	6	0	0	8	8
Driver	4	2	0	0	4	4
	64	50	46	42	60	60
Sta Tank/Mult Tgts[3]						
Commander	18	14	14	12	18	18
Gunner	30	26	30	24	30	26
Loader	12	8	0	0	10	10
Driver	4	2	0	0	4	4
	64	50	44	36	62	58
Mov Tank/Sta Tgt[4]						
Commander	16	0	10	0	16	16
Gunner	34	0	18	0	28	30
Loader	10	0	2	2	8	8
Driver	10	0	0	0	10	10
	70	0	30	2	62	64
Mov Tank/Mult Tgts[5]						
Commander	20	0	6	0	20	20
Gunner	34	0	6	0	34	30
Loader	12	0	0	0	10	10
Driver	10	0	0	0	10	10
	76	0	12	0	74	70
Mov Tank/Simul Tgts[6]						
Commander	16	0	4	0	10	16
Gunner	30	0	4	0	28	26
Loader	10	0	0	0	8	8
Driver	4	0	0	0	4	4
	60	0	8	0	50	54
Totals	390	140	180	112	362	356

1 Stationary Tank/Stationary Target
2 Stationary Tank/Moving Target
3 Stationary Tank/Multiple Targets
4 Moving Tank/Stationary Target
5 Moving Tank/Multiple Targets
6 Moving Tank/Simultaneous Targets

TABLE 4. UTILITY OF TANK GUNNERY SIMULATORS - TASKS VALUED EQUALLY (1)

Type of Engagement and Crew Member	Maximum Score	Simulator				
		TGMTS	M-COFT	VIGS	TWGSS	GF1
Sta Tank/Sta Tgt[1]						
Commander	12	9	10	9	12	12
Gunner	18	16	18	16	18	16
Loader	11	9	0	0	10	10
Driver	4	2	0	0	4	4
	45	36	28	25	44	42
Sta Tank/Mov Tgt[2]						
Commander	12	9	9	8	11	12
Gunner	21	19	21	20	21	20
Loader	11	9	0	0	10	10
Driver	4	3	0	0	4	4
	48	40	30	28	46	46
Sta Tank/Mult Tgts[3]						
Commander	15	12	12	12	15	15
Gunner	19	17	19	16	19	17
Loader	12	10	0	0	11	11
Driver	4	3	0	0	4	4
	50	42	31	28	49	47
Mov Tank/Sta Tgt[4]						
Commander	13	0	9	0	13	13
Gunner	21	0	12	0	18	19
Loader	11	0	1	1	9	10
Driver	6	0	0	0	6	6
	51	0	22	1	46	48
Mov Tank/Mult Tgts[5]						
Commander	16	0	8	0	16	16
Gunner	21	0	4	0	21	19
Loader	12	0	0	0	11	11
Driver	6	0	0	0	6	6
	55	0	12	0	54	48
Mov Tank/Simul Tgts[6]						
Commander	13	0	3	0	10	13
Gunner	20	0	4	0	19	18
Loader	10	0	0	0	9	9
Driver	2	0	0	0	2	2
	45	0	7	0	40	42
Totals	294	118	130	82	279	277

1 Stationary Tank/Stationary Target
2 Stationary Tank/Moving Target
3 Stationary Tank/Multiple Targets
4 Moving Tank/Stationary Target
5 Moving Tank/Multiple Targets
6 Moving Tank/Simultaneous Targets

B. COSTS

Average unit costs of the five simulator trainers were provided by the Armor School (Ref. 19). These costs, which were previously provided the Armor School by the Army's Office of the Project Manager for Training Devices (PM-TRADE), are shown in Table 5.

TABLE 5. EXPECTED UNIT COSTS OF TANK GUNNERY SIMULATORS

Trainer	Cost, thousands of FY 1986 $
TGMTS	125
M-COFT	1900
VIGS	14[a]
TWGSS	100
GF1	96[b]

[a] Estimated average cost of simulators for Reserve M60A3 training.

[b] Includes $84K for GF1 and $12K for three Electronic Information Delivery System (EIDS) units, which are to be included as government-furnished equipment.

III. RESULTS

Table 6 summarizes the different value systems used in Tables 2, 3, and 4 for assessing the utility of the tank gunnery simulators. Simulator costs from Table 5 are then divided by the Table 6 utility scores to determine the cost-per-task-trained for the simulators in Table 7.

TABLE 6. COMPARATIVE UTILITY OF TANK GUNNERY SIMULATORS

Value System for Determining Utility Score	Maximum Score	Simulator				
		TGMTS	M-COFT	VIGS	TWGSS	GF1
More important tasks are assigned values of 2; other tasks are assigned values of 1	489	188	220	139	460	455
Only tasks with value 2 are counted	390	140	180	112	362	356
All tasks are valued equally and assigned values of 1	294	118	130	82	279	277

TABLE 7. COMPARATIVE COST PER TASK TRAINED OF TANK GUNNERY SIMULATORS

Value System for Determining Utility Score	Simulator and Cost in FY 1986 $				
	TGMTS $125,000	M-COFT $1,900,000	VIGS $14,000	TWGSS $100,000	GF1 $96,000
More important tasks are assigned values of 2, other tasks are assigned values of 1	665	8,636	101	217	211
Only tasks with value 2 are counted	893	10,556	125	276	270
All tasks are valued equally and assigned values of 1	1,059	14,615	171	358	347

APPENDIX A

TANK GUNNERY SIMULATORS

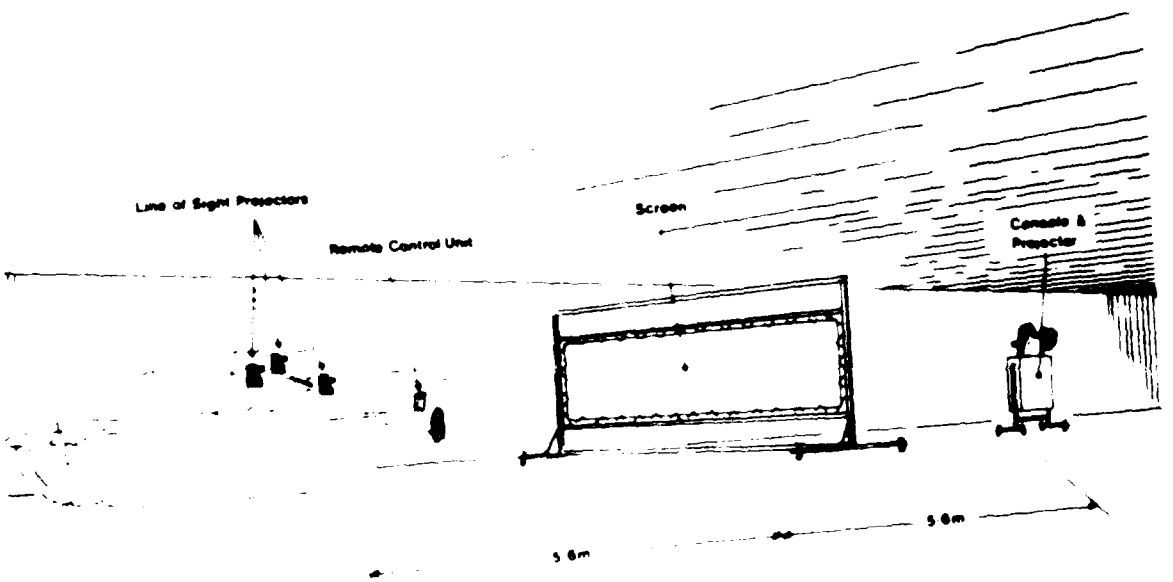
Tank Gunnery and Missile Tracking System (TGMTS)[1]

The TGMTS is a rear screen projection system that provides a film presentation of actual armor vehicles in a realistic scenario. Single and multiple targets can be displayed at various ranges and speeds. The screen is placed in front of a single tank (see Fig. A-1). The tank fire control system is manipulated to simulate main gun (primary) and machine gun (secondary) firing with a computer-controlled, eye-safe laser device. Line of sight projectors are attached to the primary and secondary sights. A laser impact projector, connected to an infrared scanning mechanism, continuously tracks the gunner's aiming point. At the instant of trigger pull, trajectory simulation is based on the gunner's aiming point and on ballistic data applied from a mini-computer. The precise position of the fired round is shown during flight. At the instant of impact, a brilliant point of laser light appears.

The primary value of TGMTS is that it allows gunner and tank commander coordination during engagement exercises. Adjustment of fire can be made as the gunner and tank commander receive a positive hit indication. Both battlesight and precision engagement techniques may be used with TGMTS. A drawback of this system is that it does not provide own tank motion capabilities, therefore limiting practice to stationary tank engagements only.

Special facilities are required. A facility must be large enough to accommodate a tank, rear projection movie screen, and 16mm projector. Normally, a facility 20' x 60' is adequate. It must also have a power source for the projector and exhaust vents for the tank when the engine is running.

[1] Source: Refs. 5 and 6.



TANK GUNNERY AND MISSILE TRACKING SYSTEM

Figure A-1. Tank Gunnery and Missile Tracking System

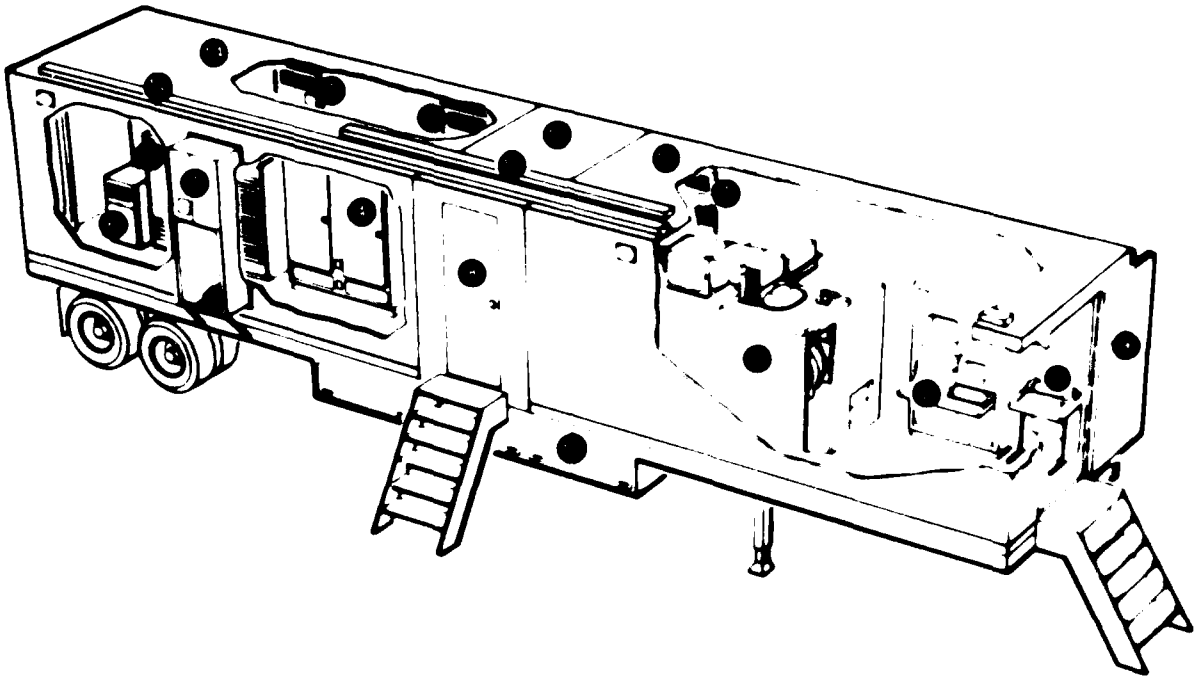
Mobile Conduct of Fire Trainer (M-COFT)[1]

The M-COFT is a trailer-mounted adaptation of the Unit Conduct of Fire Trainer (U-COFT) to provide training of tank commander-gunner teams of main battle tanks and Bradley fighting vehicles in operational procedures and target acquisition, identification, and engagement (see Fig. A-2). The COFT gunnery simulator uses computer-based visual simulation technology to produce full-color action scenes in which tank crew members can see and interact in dynamic multiple target situations.

In its crew compartment, the COFT has training stations for the tank commander and the gunner. Its computer-stabilized fire control system supports accurate firing while the simulated tank is moving. The crew stations provide the appearance and functions of the tank's operating controls, indicators, and weapons sights. Characteristics such as field of view, magnification selection, sight reticles, and filter/shutter appearance are all realistically simulated. Audible effects include engine and drive train whine, track clatter, clank of the breechblock, as well as gun firing and the sound of spent brass falling on the deck.

Computer-generated images represent the scenes viewed by crew members training in the simulator. The special purpose computer image generator provides full-color, dynamic, daylight and nighttime scenes with various terrain and topographical backgrounds, man-made structures, moving targets, tracers, and special effects that allow tank crews to develop gunnery proficiency in a broad range of simulated battle conditions. Correct visual perspective is instantaneously computed and maintained for all orientations of the tank relative to its targets. The "own-tank" can move freely within the scene, allowing full simulation of tank tactics. Computer-generated

[1] Source: Refs. 5, 6, 7, and 8



M-COFT Flatbed Trailer Configuration

1. CREW STATION
2. INSTRUCTOR OPERATOR STATION (IOS)
3. PRINTER
4. SPECIAL PURPOSE COMPUTER
5. GENERAL PURPOSE COMPUTER
6. DISK
7. AIR CONDITIONER
8. TRAINING ENTRANCE
9. EMERGENCY EXIT
10. STORAGE
11. WALKWAY
12. INTER SHELTER POWER CABLE
13. INTER SHELTER SIGNAL CABLE
14. COMPUTER SHELTER
15. CREW COMPARTMENT SHELTER

MOBILE CONDUCT OF FIRE
TRAINER (MCOFT)

Figure A-2. Mobile Conduct of Fire Trainer

weaponry effects (e.g., main gun recoil) enable the COFT to represent programmable battle situations in real time.

The following components of its instructional subsystem account for much of the training capability of the COFT: (1) a library of preprogrammed exercises for teaching skills in target acquisition, reticle aiming, and tank systems management; (2) an adaptive evaluation system for measuring crew progress; (3) a training management system to process trainee records and assist in scheduling; and (4) an instructor/operator station (IOS) to provide an instructor with real-time instructional feedback and with controls for monitoring and critiquing trainee actions.

The library of preprogrammed exercises consists of targets integrated into realistic tactical battlefields. Exercises require the tank commander and the gunner to perform all crew actions required by variations in target type and number, range, weather and target motion, visibility and other complex conditions. The flexibility of the training programs allows tank commanders and gunners to practice critical skills. It also allows drivers and loaders to cross-train in the duties of gunner. Familiarization of all crewmen in the duties of the tank commander can be practiced to provide cross-trained members within a tank crew.

As initiated at the IOS, the training exercises and associated evaluation of performance. Full-color video displays are provided at the IOS so that the instructor can monitor the same scenes presented to the tank commander and gunner. The IOS incorporates a keyboard terminal and display system to initiate, control, and monitor the activities of the tank commander and gunner. Trainee performance, accuracy, and response time, are measured and displayed at the IOS. An intercom system allows the instructor to communicate with the trainees and to simulate radio transmissions. Simulated malfunctions are preprogrammed into the training situations.

Videodisc Gunnery Simulator (VIGS)[1]

The VIGS is a table-top device (see Fig. A-3) that trains gunners in (1) gun system utilization and (2) the techniques of target engagement. This device provides controls and displays similar to those on an actual armored vehicle (main battle tank or Bradley fighting vehicle) and a realistic through-the-sight view of the engagement area. The VIGS training focuses on tasks that a gunner performs in engaging a target: acquiring, identifying, gun-laying, ranging, tracking, leading, firing, and adjusting.

On the console of controls and displays, a scoreboard tells the gunner what he did right and wrong in an engagement.

A videodisc player and a library of videodiscs provide the visual scenes which the gunner sees through his sight. Each videodisc has a number of short (20-40 seconds long) engagements. An engagement is a motion picture of one or more actual tanks or other armor vehicles in a battlefield environment. In most engagements actual Threat vehicles, such as T-62s, are shown. For each engagement a fire command is recorded on the audio track of the videodisc.

Floppy discs (one per videodisc) and a floppy disc drive provide the information which a small microcomputer in the gunner's console needs to run the simulation. This includes information about the target's location and behavior at any point in time during an engagement (such as, ammunition load and ballistics).

[1] Source: Ref. 5.

Immediately after his score is displayed, the gunner is shown--through his sight--a still frame of the target of the preceding engagement. A series of graphic dots appear around or on the target, one at a time, representing in sequence where each round hit with respect to the target. After studying his shot group, the soldier can then press a CLEAR key on the scoreboard key pad. The scoreboard will then display, on a round-by-round basis, how many mils and in what direction he was off in elevation and deflection, how long he took to fire, and what ammunition he had indexed.

Once he has reviewed his performance, the gunner presses the START key and begins the next engagement. His training session ends when he has expended all of the ammunition allotted. The session can be repeated by pressing a RELOAD key on the scoreboard key pad.

Course material for the VIGS presently consists of three videodiscs, each of which contains approximately 20 engagements. The engagements typically show one or more Threat vehicles at ranges between 800 and 3,000 meters. A special videodisc has been provided to present bridges, bunkers, walls, and other obstacles as targets.

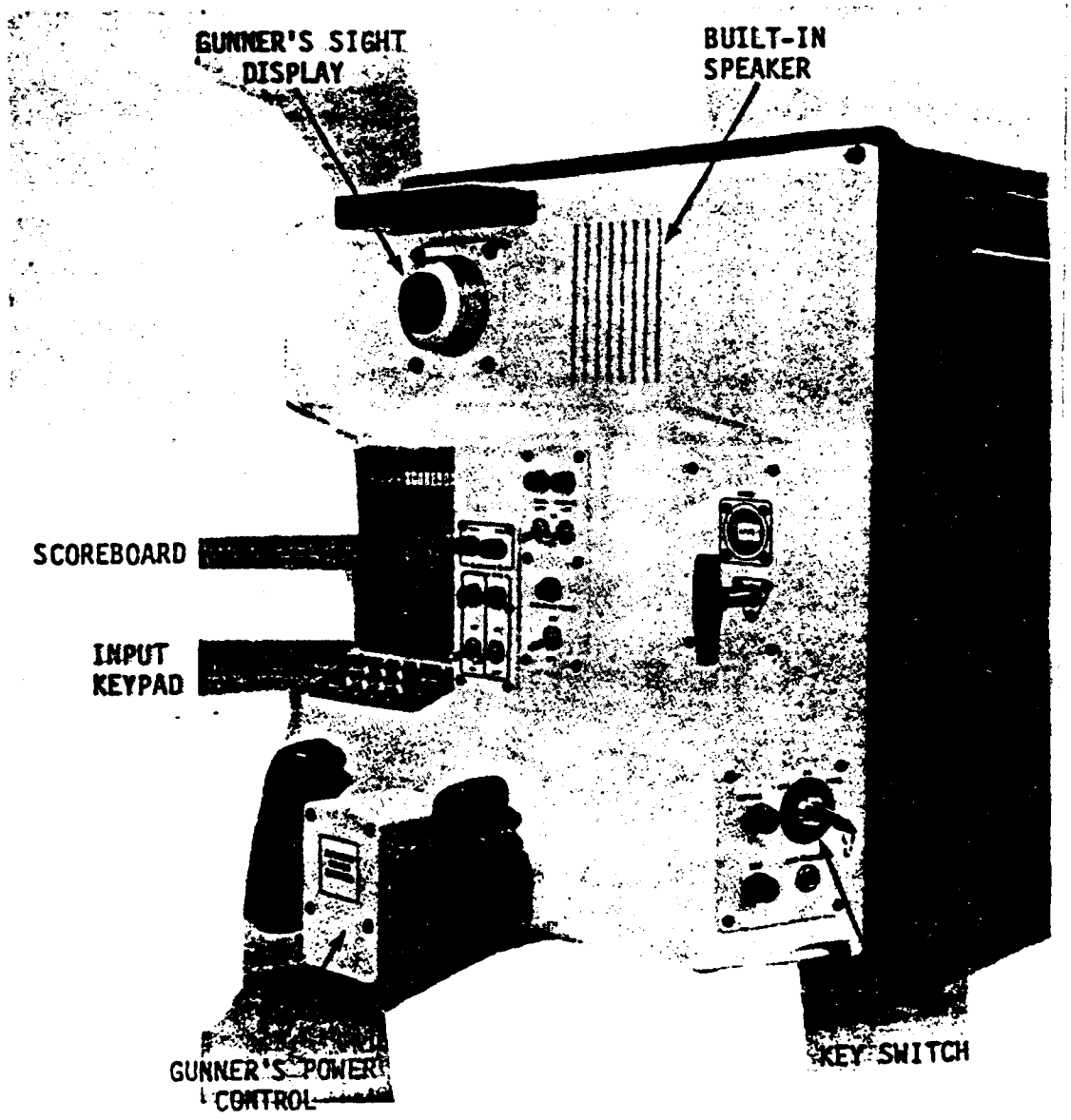


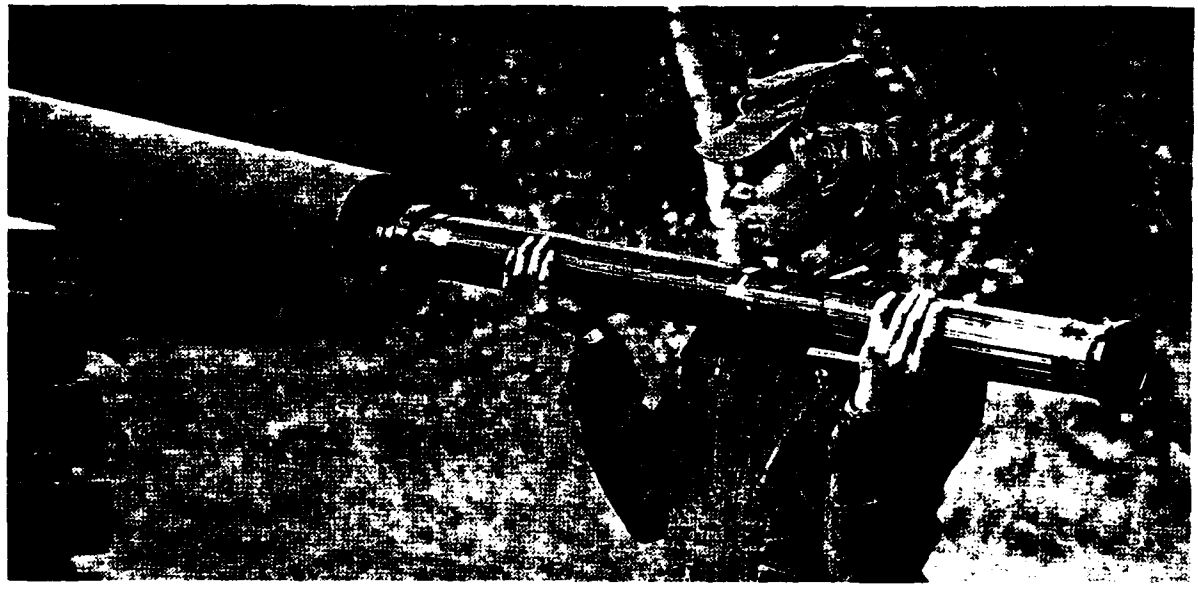
Figure A-3. Videodisc Gunner Simulator (VIGS)

Tank Weapons Gunnery Simulation System (TWGSS)[1]

The TWGSS is a tank-mounted gunnery training system for simulating main gun firing. It will interface with the tank fire control system to permit precision gunnery to be practiced with lead, superelevation, range, and type ammunition considered. Indications of simulated tracer and impact will be superimposed in the sight picture. Obscuration during firing, sight displacement, and target effects will also be simulated. A crew evaluation subsystem will be included to provide a hard copy record of the engagement. It will enable the trainer to reconstruct the firing sequence in order to evaluate and critique tank crew performance. The TWGSS will be used with MILES (multiple integrated laser equipment system) for combined arms exercises; and it will interface with an eye-safe laser rangefinder for safe force-on-force exercises.

The Army is evaluating several candidate tank-mounted simulators that are already in use by European armies to fulfill the U.S. requirement for a precision gunnery training system that requires minimal R&D. While similarities and dissimilarities of the TWGSS candidates are not known, an ongoing evaluation will determine which system best suits the TWGSS requirement. To illustrate the TWGSS concept, Figs. A-4 and A-5 show parts--gun-tube-mounted laser emitter (top) and target-mounted hit sensors and visual indicators (bottom)--of the Swedish BT-41, a Saab-developed candidate.

[1] Source: Refs. 5, 6, and 7.



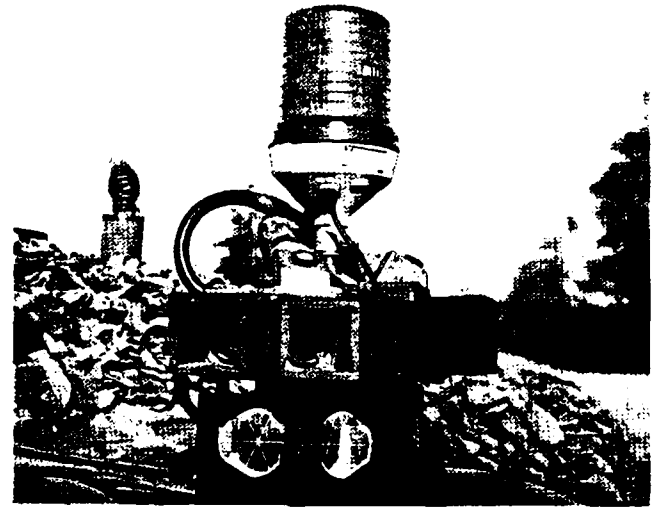
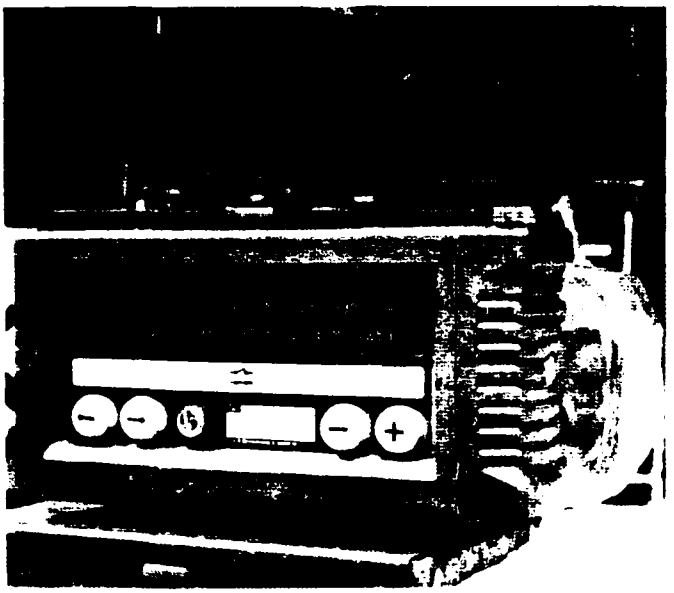


Figure A-4. Some BT-41 Components



```
AMMO: APDS  REM.   32
RANGE:  2186 m
ELEV:   ↑   .5 m
AZIM:   → 3.6 m
1981 10 11  10 16 56

HIT: ID:03 AM 15
TURRET: 15°
ELEV:   ↑   ,5 m
AZIM:   → 3,2 m
KILL PROB.  45 %
1981 10 11  10 17 08

AMMO: HEAT  REM.   8
RANGE:   892 m
ELEV:   ↑ 2,2 m
AZIM:   →   ,7 m
1981 10 11  10 17 14

HIT: ID:08 AM 15
TURRET: 15°
ELEV:   ↑ 1,1 m
AZIM:   →   ,2 m
*** DESTRUCTION
1981 10 11  10 17 19
```

Type of ammunition fired.
Remaining number of rounds
Range to target.
Fall of shot.
Identity of attacking tank.
Lethality code of fired ammunition
Direction of fire relative to turret.
Point of impact.
Probability of kill
Year. Month. Day.
Hour. Minute. Second.

Figure A-5. BT-41 Display and Printout

Guardfist 1 (GF1)[1]

The GF1 concept was proposed by the Army National Guard to provide realistic, stress-filled combat simulation training at the armory. The device is tank-mounted to provide realistic tactile sensations and is designed to allow each crew member to attain and sustain skills required by each duty position--viz., tank commander, gunner, loader, and driver. The Army's EIDS (electronic information delivery system), a microprocessor utilizing videodisc technology, will--with appropriate modification to suit local area networks--provide crewmen a series of interactive battlefield scenarios for gunnery, driving, and tactical exercises.

The GF1 device will train crew tasks that are performed in basic and intermediate tank gunnery exercises. The intermediate level exercises (Tables V through VIII) train and sustain the tank crew's ability to engage moving and stationary targets with all tank-mounted weapons, during periods of daylight and darkness. The firing tank simulates movement using the terrain to gain tactical advantage, engaging single, multiple, and simultaneous target arrays.

The GF1 concept originated because of recognition that critical interactions among tank crew members in the Army reserve components were practiced primarily during full caliber gunnery training exercises, which were too infrequent to provide enough training to achieve and maintain crew proficiency. The principal rational for GF1 was that TGMTS, M-COFT, or VIGS would not provide the requisite amount of full-crew interactive training.

[1] Source: Ref. 9.

APPENDIX B

UTILITY RATINGS OF FIVE TANK GUNNERY SIMULATORS FOR TRAINING SPECIFIED TANK CREW DUTIES

NOTE: The second column, "Rating," in the tables of this Appendix reflects the value 1 or 2 that Armor School master gunners assigned to the tank crew duties indicated. A blank space for the TGMTS, M-COFT, VIGS, TWGSS, or GF1 simulator means that device will not train the duty indicated.

TABLE B-1. CREW DUTIES FOR STATIONARY TANK VS. STATIONARY TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Acquire/Identify Target	2	2		2	2	2
Issue Fire Command	1	1	1	1	1	1
Lay Gun for Direction	2	2	2		2	2
Determine Range to Target Using Tank-Mounted Range Finder	2		2	2	2	2
Estimate Range	1			1	1	1
Command "Fire"	1	1	1	1	1	1
Fire Precision Engagement from TC Position (if required)	2	2	2		2	2
Fire Battlesight Engagement from TC Position (if required)	2		2		2	2
Observe Round	2	2	2	2	2	2
Issue Subsequent Fire Command	1	1	1	1	1	1
Observe Target Hit	2	2	2	2	2	2
Command "Target Cease Fire"	1	1	1	1	1	1
Totals[a]	12/19	9/14	10/16	9/13	12/19	12/19

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-1. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Search for and Acquire Targets	2	2	2	2	2	2
Operate Turret in Power	2	2	2	2	2	2
Index Announced Ammunition	2	2	2	2	2	2
Turn on Main Gun Switch	2	2	2	2	2	2
Identify Target	2	2	2	2	2	2
Announce "Identified"	1	1	1	1	1	1
Take up Proper Sight Picture	2	2	2	2	2	2
Announce "On the Way"	1	1	1	1	1	1
Fire Round Using Primary Sight for Battlesight Gunnery	2		2	2	2	2
Fire Round Using Primary Sight for Precision Gunnery	2	2	2	2	2	2
Fire Round Using Secondary Sight for Precision Gunnery	2	2	2		2	
Fire Round Using Secondary Sight for Battlesight Gunnery	2		2		2	
Observe Round	2	2	2	2	2	2
Re-lay on Target and Apply TC Adjustment	2	2	2	2	2	2
Announce "On the Way"	1	1	1	1	1	1
Fire Subsequent Round	2	2	2	2	2	2
Observe Round	2	2	2	2	2	2
Turn Main Gun Switch Off	1	1	1	1	1	1
Totals	18/32	16/28	18/32	16/29	18/32	16/28

TABLE B-1. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Observe for Targets	2	2			2	
Arm Weapon with Main Gun Safety Switch	2	2			2	2
Announce "Up"	1	1			1	1
Turn Turret Blower On	1	1			1	1
Prepare to Load Subsequent Round	1	1			1	1
Operate Main Gun Safety Switch	2				2	2
Load Next Round	2					2
Arm Weapon System	2	2			2	2
Announce "Up"	1	1			1	1
Turn Turret Blower Off	1	1			1	1
Check Replenisher Reservoir	1	1			1	1
Totals	11/16	9/12	0/0	0/0	10/14	10/14

TABLE B-1. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Maintain Engine RPM/ Steady Platform	2				2	2
Lock Brakes	1	1			1	1
Monitor Improvement Panel	1	1			1	1
Respond to TC Driving Instructions	2				2	2
Totals	4/6	2/2	0/0	0/0	4/6	4/6

TABLE B-2. CREW DUTIES FOR STATIONARY TANK VS. MOVING TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GFl
Acquire/Identify Target	2	2		2	2	2
Issue Fire Command	1	1	1		1	1
Lay Gun for Direction	2	2	2	2	2	2
Determine Range to Target Using Tank-Mounted Range Finder	2		2			2
Estimate Range	1			1	1	1
Command "Fire"	1	1	1	1	1	1
Fire Precision Engagement from TC Position (if required)	2	2	2		2	2
Fire Battlesight Engagement from TC Position (if required)	2		2		2	2
Observe Round	2	2	2	2	2	2
Issue Subsequent Fire Command	1	1	1	1	1	1
Observe Target Hit	2	2		2	2	2
Command "Target Cease Fire"	1	1	1	1	1	1
Totals[a]	12/19	9/14	9/14	8/12	11/17	12/19

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-2. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GFI
Search for and Acquire Targets	2	2	2	2	2	2
Operate Turret in Power	2	2	2	2	2	2
Index Announced Ammunition	2	2	2	2	2	2
Turn on Main Gun Switch	2	2	2	2	2	2
Identify Target	2	2	2	2	2	2
Announce "Identified"	1	1	1	1	1	1
Track Target	2	2	2	2	2	2
Take up Proper Sight Picture (Apply Proper Load)	2	2	2	2	2	2
Continue Tracking	2	2	2	2	2	2
Fire Round Using Primary Sight for Battlesight Gunnery	2		2	2	2	2
Fire Round Using Primary Sight for Precision Gunnery	2	2	2	2	2	2
Fire Round Using Secondary Sight for Precision Gunnery	2		2		2	
Observe Round	2	2	2	2	2	2
Continue Tracking	2	2	2	2	2	2
Re-lay Using Precision Gunnery and Re-engage	2	2	2	2	2	2
Re-lay on Target and Apply TC Adjustment	2	2	2	2	2	2
Announce "On the Way"	1	1	1	1	1	1
Continue Tracking	2	2	2	2	2	2
Fire Subsequent Round	2	2	2	2	2	2
Observe Round	2	2	2	2	2	2
Turn Main Gun Switch Off	1	1	1	1	1	1
Totals	21/39	19/35	21/39	20/37	21/39	20/37

TABLE B-2. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GFl
Observe for Targets	2	2			2	
Arm Weapon with Main Gun Safety Switch	2	2			2	2
Announce "Up"	1	1			1	1
Turn Turret Blower On	1	1			1	1
Prepare to Load Subsequent Round	1	1			1	1
Operate Main Gun Safety Switch	2				2	2
Load Next Round	2					2
Arm Weapon System	2	2			2	2
Announce "Up"	1	1			1	1
Turn Turret Blower Off	1	1			1	1
Check Replenisher Reservoir	1	1			1	1
Totals	11/16	9/12	0/0	0/0	10/14	10/14

TABLE B-2. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GFl
Maintain Engine RPM/ Steady Platform	2	2			2	2
Lock Brakes	1	1			1	1
Monitor Improvement Panel	1	1			1	1
Respond to TC Driving Instructions	2				2	2
Totals	4/6	3/4	0/0	0/0	4/6	4/6

TABLE B-3. CREW DUTIES FOR STATIONARY TANK VS. MULTIPLE TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Acquire/Identify Target	2	2		2	2	2
Determine Most Dangerous Target	2	2	2	2	2	2
Issue Fire Command	1	1	1	1	1	1
Lay Gun for Direction	2	2	2		2	2
Determine Range to Target Using Tank-Mounted Range Finder	2		2	2	2	2
Estimate Range	1			1	1	1
Command "Fire"	1	1	1	1	1	1
Fire Precision Engagement from TC Position (if required)	2	2	2		2	2
Fire Battlesight Engagement from TC Position (if required)	2		2		2	2
Observe Round	2	2	2	2	2	2
Issue Subsequent Fire Command	1	1	1	1	1	1
Observe Target Hit	2	2		2	2	2
Command "Target--(left, right, or center) Tank"	1	1	1	1	1	1
Repeat Above Sequence Until All Targets are Destroyed	2	2	2	2	2	2
Command "Target Cease Fire"	1	1	1	1	1	1
Totals[a]	15/24	12/19	12/19	12/18	15/24	15/24

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-3. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Search for and Acquire Targets	2	2	2	2	2	2
Operate Turret in Power	2	2	2		2	2
Index Announced Ammunition	2	2	2	2	2	2
Turn on Main Gun Switch	2	2	2	2	2	2
Identify Target	2	2	2	2	2	2
Announce "Identified" (Track Target if required)	1	1	1	1	1	1
Take up Proper Sight Picture (Apply Lead if required)	2	2	2	2	2	2
Announce "On the Way" (Continue Tracking if Required	1	1	1	1	1	1
Fire Round Using Primary Sight for Battlesight Gunnery	2		2	2	2	2
Fire Round Using Primary Sight for Precision Gunnery	2	2	2	2	2	2
Fire Round Using Secondary Sight for Precision Gunnery	2	2	2		2	
Fire Round Using Secondary Sight for Battlesight Gunnery	2		2		2	
Observe Round	2	2	2	2	2	2
Re-lay on Target and Apply TC Adjustment	2	2	2	2	2	2
Announce "On the Way"	1	1	1	1	1	1
Fire Subsequent Round	2	2	2	2	2	2
Observe Round	2	2	2	2	2	2
Repeat Above Sequence Under TC's Direction Until "Cease Fire" is Commanded	2	2	2	2	2	2
Turn Main Gun Switch Off	1	1	1	1	1	1
Totals	19/34	17/30	19/34	16/28	19/34	17/30

TABLE B-3. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Observe for Targets	2	2			2	
Arm Weapon with Main Gun Safety Switch	2	2			2	2
Announce "Up"	1	1			1	1
Turn Turret Blower On	1	1			1	1
Prepare to Load Subsequent Round	1	1			1	1
Operate Main Gun Safety Switch	2				2	2
Load Next Round	2					2
Arm Weapon System	2	2			2	2
Announce "Up"	1	1			1	1
Repeat Above Sequence Under TC's Direction	2	2			2	2
Turn Turret Blower Off	1	1			1	1
Check Replenisher Reservoir	1	1			1	1
Totals	12/18	10/14	0/0	0/0	11/16	11/16

TABLE B-3. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Maintain Engine RPM/ Steady Platform	2	2			2	2
Lock Brakes	1	1			1	1
Monitor Improvement Panel	1	1			1	1
Respond to TC Driving Instructions	2				2	2
Totals	4/6	3/4	0/0	0/0	4/6	4/6

TABLE B-4. CREW DUTIES FOR MOVING TANK VS. STATIONARY TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Acquire/Identify Target	2				2	2
Issue Fire Command	1		1		1	1
Direct Driver Toward Target	2				2	2
Lay Gun for Direction	2		2		2	2
Determine Range to Target Using Tank-Mounted Range Finder	2		2		2	2
Estimate Range	1				1	1
Command "Fire"	1		1		1	1
Fire Precision Engagement from TC Position (if required)	2		2		2	2
Fire Battlesight Engagement from TC Position (if required)	2		2		2	2
Observe Round	2		2		2	2
Issue Subsequent Fire Command	1		1		1	1
Observe Target Hit	2				2	2
Command "Target Cease Fire"	1		1		1	1
Totals[a]	13/21	0/0	9/14	0/0	13/21	13/21

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-4. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Search for and Acquire Targets	2		2		2	2
Operate in Stabilized Mode	2		2		2	2
Operate Turret in Power	2		2		2	2
Index Announced Ammunition	2		2		2	2
Turn on Main Gun Switch	2		2		2	2
Identify Target	2		2		2	2
Announce "Identified"	1		1		1	1
Track Target	2		2		2	2
Take up Proper Sight Picture (Apply Lead if required)	2		2		2	2
Announce "On the Way" (If Required Continue Tracking)	1		1		1	1
Fire Round Using Primary Sight for Battlesight Gunnery	2				2	2
Fire Round Using Primary Sight for Precision Gunnery	2		2		2	2
Fire Round Using Secondary Sight for Precision Gunnery	2					
Fire Round Using Secondary Sight for Battlesight Gunnery	2					
Observe Round	2					2
Continue Tracking (if required)	2				2	2
Re-lay on Target and Apply TC Adjustment	2				2	2
Announce "On the Way"	1				1	1
Fire Subsequent Round	2				2	2
Observe Round	2				2	2
Turn Main Gun Switch Off	1		1		1	1
Totals	21/38	0/0	12/21	0/0	18/32	19/34

TABLE B-4. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Observe for Targets	2				2	
Arm Weapon with Main Gun Safety Switch	2				2	2
Announce "Up"	1				1	1
Turn Turret Blower On	1				1	1
Prepare to Load Subsequent Round	1				1	1
Operate Main Gun Safety Switch	2		2	2	2	2
Load Next Round	2					2
Arm Weapon System	2				2	2
Announce "Up"	1					1
Turn Turret Blower Off	1				1	1
Check Replenisher Reservoir	1				1	1
Totals	11/16	0/0	1/2	1/2	9/13	10/14

TABLE B-4. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Drive Tactically	2				2	2
Orient Front Slope Toward Target	2				2	2
Maintain Steady Speed and Direction	2				2	2
Monitor Instrument Panel	1				1	1
Alert Crew of Obstacles	2				2	2
Respond to TC Driving Instructions	2				2	2
Totals	6/11	0/0	0/0	0/0	6/11	6/11

TABLE B-5. CREW DUTIES FOR MOVING TANK VS. MULTIPLE TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Acquire/Identify Target	2				2	2
Determine Most Dangerous Target	2		2		2	2
Issue Fire Command	1		1		1	1
Direct Driver Toward Target	2				2	2
Lay Gun for Direction	2		2		2	2
Determine Range to Target Using Tank-Mounted Range Finder	2		2		2	2
Estimate Range	1				1	1
Command "Fire"	1		1		1	1
Fire Precision Engagement from TC Position (if required)	2				2	2
Fire Battlesight Engagement from TC Position (if required)	2				2	2
Observe Round	2				2	2
Issue Subsequent Fire Command	1		1		1	1
Observe Target Hit	2				2	2
Command "Target--(left, right, or center) Tank"	1		1		1	1
Repeat Above Sequence Until All Targets are Destroyed	2				2	2
Command "Target Cease Fire"	1		1		1	1
Totals[a]	16/26	0/0	8/11	0/0	16/26	16/26

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-5. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Search for and Acquire Targets	2		2		2	2
Operate in Stabilized Mode	2				2	2
Operate Turret in Power	2				2	2
Index Announced Ammunition	2				2	2
Turn on Main Gun Switch	2		2		2	2
Identify Target	2				2	2
Announce "Identified" (Track Target if required)	1				1	1
Take up Proper Sight Picture (Apply Lead if required)	2				2	2
Announce "On the Way"	1				1	1
Fire Round Using Primary Sight for Battlesight Gunnery	2				2	2
Fire Round Using Primary Sight for Precision Gunnery	2				2	2
Fire Round Using Secondary Sight for Precision Gunnery	2				2	
Fire Round Using Secondary Sight for Battlesight Gunnery	2				2	
Observe Round	2				2	2
Continue Tracking (if required)	2		2		2	2
Re-lay on Target and Apply TC Adjustment	2				2	2
Announce "On the Way"	1				1	1
Fire Subsequent Round	2				2	2
Observe Round	2				2	2
Repeat Above Sequence Under TC's Direction Until "Cease Fire" is Commanded	2				2	2
Turn Main Gun Switch Off	1		1		1	1
Totals	21/38	0/0	4/7	0/0	21/38	19/34

TABLE B-5. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Observe for Targets	2				2	
Arm Weapon with Main Gun Safety Switch	2				2	2
Announce "Up"	1				1	1
Turn Turret Blower On	1				1	1
Prepare to Load Subsequent Round	1				1	1
Operate Main Gun Safety Switch	2				2	2
Load Next Round	2					2
Arm Weapon System	2				2	2
Announce "Up"	1				1	1
Repeat Above Sequence Under TC's Direction	2				2	2
Turn Turret Blower Off	1				1	1
Check Replenisher Reservoir	1				1	1
Totals	12/18	0/0	0/0	0/0	11/16	11/16

TABLE B-5. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Drive Tactically	2				2	2
Orient Front Slope Toward Target	2				2	2
Maintain Steady Speed and Direction	2				2	2
Monitor Instrument Panel	1				1	1
Alert Crew of Obstacles	2				2	2
Respond to TC Driving Instructions	2				2	2
Totals	6/11	0/0	0/0	0/0	6/11	6/11

TABLE B-6. CREW DUTIES FOR MOVING TANK VS. SIMULTANEOUS TARGET ENGAGEMENT

Tank Commander (TC) Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Acquire/Identify Target	2				2	2
Issue Fire Command	1				1	1
Lay Gun for Direction	2				2	2
Determine Range to Main Gun Target Using Tank-Mounted Range Finder	2		2		2	2
Estimate Range	1				1	1
Command "Fire and Adjust"	1		1		1	1
Announce "Caliber Fifty"	1				1	1
Determine Range to Caliber .50 Target	2				2	2
Engage Target	2				2	2
Observe Caliber .50 Rounds	2					2
Adjust Tracers onto Target	2		2			2
Observe Target Hit	2					2
Announce "TC Complete"	1				1	1
Totals[a]	13/21	0/0	3/5	0/0	10/15	13/21

[a] For each entry A/B, A reflects equal values of 1 for each duty and B reflects weighted values of 1 or 2 for each duty.

TABLE B-6. CONTINUED

Gunner Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Search for and Acquire Targets	2		2		2	2
Operate in Stabilized Mode	2				2	2
Operate Turret in Power	2				2	2
Index Announced Ammunition	2				2	2
Turn on Main Gun Switch	2		2		2	2
Identify Target	2				2	2
Announce "Identified" (Track Target if required)	1				1	1
Take up Proper Sight Picture (Apply Lead if required)	2				2	2
Announce "On the Way"; Continue Tracking (If Required)	1		1		1	1
Fire Round Using Primary Sight for Battlesight Gunnery	2				2	2
Fire Round Using Primary Sight for Precision Gunnery	2				2	2
Fire Round Using Secondary Sight for Precision Gunnery	2				2	
Fire Round Using Secondary Sight for Battlesight Gunnery	2				2	
Observe Round	2					2
Continue Tracking (if required)	2				2	2
Announce "On the Way"	1				1	1
Fire Subsequent Round	2				2	2
Observe Round	2				2	2
Announce "Target Cease Fire"	1				1	1
Turn Main Gun Switch Off	1		1		1	1
Totals	20/35	0/0	4/6	0/0	19/33	18/31

TABLE B-6. CONTINUED

Loader Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Observe for Targets	2				2	
Arm Weapon with Main Gun Safety Switch	2				2	2
Announce "Up"	1				1	1
Turn Turret Blower On	1				1	1
Prepare to Load Subsequent Round	1				1	1
Operate Main Gun Safety Switch	2				2	2
Load Next Round	2					2
Arm Weapon System	2				2	?
Announce "Up"	1				1	1
Turn Turret Blower Off	1				1	1
Totals	10/15	0/0	0/0	0/0	9/13	9/13

TABLE B-6. CONTINUED

Driver Duties	Rating	TGMTS	M-COFT	VIGS	TWGSS	GF1
Drive Tactically	2				2	2
Orient Front Slope Toward Target	2				2	2
Totals	2/4	0/0	0/0	0/0	2/4	2/4

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